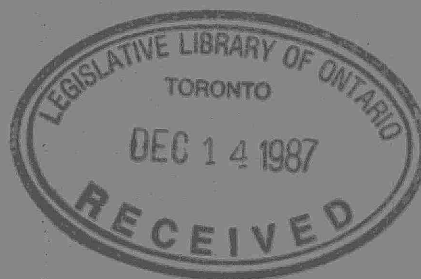


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PHYTOTOXICOLOGY STUDIES
AROUND ALUMINIUM
DROSS RECYCLING, KESWICK
1983 and 1985

ARB-062-86-Phyto

April, 1986



Ontario

Ministry
of the
Environment

E. PICHÉ, Director
Air Resources Branch

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**PHYTOTOXICOLOGY STUDIES AROUND ALUMINIUM
DROSS RECYCLING, KESWICK
1983 and 1985**

BACKGROUND

The Phytotoxicology Section has been involved in vegetation assessment studies around Aluminum Dross Recycling (ADR) in Keswick since 1975. In the past this company has also been known as Thane Development Ltd. and Continental Aluminum. ADR re-smelts waste aluminum (dross) into aluminum ingots. Occasionally this process emits smoke emissions off property which causes material discomfort to people living in the vicinity of the source. The MOE have received numerous complaints, many of which have expressed concern regarding contamination of the surrounding rural environment. Phytotoxicology studies have included chemical analysis of tree foliage and soil samples and observation of sensitive species of indigenous vegetation for symptoms of any pollution injury.

In the summers of 1983 and 1985 forage and tree foliage samples were collected for chemical analysis and in 1983 ion receptor moss bags were exposed for 4 consecutive months around the source. Phytotoxicology sampling was not conducted in 1984.

Tree Foliage

Seven sites were selected for sampling in 1983 and 1985. Six of the locations were within one km of ADR, and one site was a control situated almost 3 km to the south, upwind of the source. Figure 1 illustrates the approximate location of

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the seven tree foliage sampling sites. These sites were also sampled in 1980, although at that time foliage was collected from 8 and not 7 locations. Sample site 4 was not utilized in 1983 and 1985. Foliage was collected in triplicate from trembling aspen trees from the side of the crown facing the source. The samples were processed not washed at the Phytotoxicology laboratory and then forwarded to the MOE main laboratory for chemical analysis on a dry weight basis. Elemental analysis included aluminum (Al), calcium (Ca), chloride (Cl), copper (Cu), fluoride (F), magnesium (Mg), molybdenum (Mo), sodium (Na), lead (Pb) and sulphur (S).

The results of these analyses are summarized in Table 1. At the bottom of this table, corresponding to each column of chemical results, is the 'Upper Limit of Normal' for that chemical in background (or control) tree foliage. The Phytotoxicology 'Upper Limit of Normal' levels do not imply toxicity; rather, they are guidelines whereby a source is usually implicated if these concentrations are exceeded.

During the growing season the prevailing winds are from the southwest; therefore, emissions from ADR would tend to travel to the north-east. In both 1983 and 1985 the highest Al levels were found closest to the source, although foliar concentrations dropped off rapidly with increasing distance from ADR. None of the sampling sites exceeded the 500 ppm normal limit in 1983, but poplar foliage at site 2, (325m N) contained 1150 ppm Al in 1985. Elevated Al levels in foliage were not detected beyond 500 m from the source. The Al data are illustrated in Figure 2.

Similarly, foliar concentrations of S, Pb, F and Cu tended to be higher at the sampling sites closest ADR, but only Cu at site 2 in 1985 exceeded normal background levels. Foliage at this site contained 43 ppm, about twice the Phytotoxicology guideline of 20 ppm.

Foliar concentrations of Ca, and Mo were not related to distance or direction from the source. Magnesium levels in 1985 at site 1, 300 m NNW, averaged 5250 ppm, which although the highest of any sample site in either year, is still well below the normal limit of 7000 ppm.

The Cl and Na data were somewhat anomolous. All of the sampling sites had Cl concentrations in poplar foliage well above the background guideline and

although there was a tendency for higher levels closer to the source this was not consistent between the two sampling years. Previous Phytotoxicology experience indicates poplar may be a Cl accumulator, thus limiting its use in biomonitoring surveys involving the Cl ion.

Sodium concentrations were similarly elevated. The Upper Limit of Normal guideline was exceeded at 5 of the 7 sites in both 1983 and 1985. Sodium contamination extended about 1000 m NW and 500 m S of ADR.

The concentration of most elements tended to be higher in 1985 than in 1983.

Forage Sampling

ADR is a potential source of F and particulates. The predominant land use in the vicinity of the source is agriculture and cattle are grazed on several nearby farms. Concern was expressed regarding the possibility of forage contamination, and thus the 1983 Phytotoxicology survey was expanded to include six forage sample sites from grazed pastures. The forage sampling was repeated in 1985. Forage was collected in triplicate and analyzed (not washed) for the same 10 chemical elements as the tree foliage.

Figure 3 illustrates the approximate location of the six forage sites. The forage chemical analyses results are summarized in Table 2. Phytotoxicology Upper Limits of Normal guidelines have not been established for Al, Ca, Mg and Na, but the results can be compared to the control site 6, 5000 m southwest of ADR.

The Al forage concentrations were very high, exceeding 500 ppm at the site closest to ADR in both years. However, like the foliage data, the concentrations decreased with distance from the source. The exception was site 5, 1625 m NE, which in 1985 had Al forage levels averaging 205 ppm, several times higher than the concentrations detected at the control site 6. The forage Al levels are illustrated in Figure 4.

Copper, F and Pb levels in forage also were highest close to the source, although the F and Pb levels were only marginally elevated. Forage Cu levels exceeded the Phytotoxicology guideline at both sites 1 and 2 in both 1983 and 1985. Fluoride and Pb contamination did not extend farther than about 250 m from ADR and Cu contamination extended approximately 500 m from the source.

The levels of S, Mo, and Mg did not exceed normal background values nor were they significantly higher at sites closer to ADR than the control site. Calcium concentrations in forage were marginally elevated at sites closest to ADR.

The levels of Na and Cl in forage, like those in foliage, were anomalously elevated; however a contamination gradient was evident relative to ADR.

The Phytotoxicology Section has conducted two investigations regarding forage contamination and cattle health on a farm in the vicinity of ADR. Extensive chemical analysis, including all of the elements in Tables 1 and 2 of this report, were conducted on forage from this farm. The chemical concentrations were similar to, or higher, than those reported for forage in this report. These chemical data were reviewed by dairy cattle specialists with the Ministry of Agriculture and Food and found to be acceptable for cattle consumption. Aluminum, the element of main concern in forage around ADR, is considered to be toxicologically inert, except in cases of very high acute dosage and prolonged inhalation. Aluminum salts are often fed to cattle when fluorosis is a possibility because of high F content of the forage. Aluminum binds with F chemically in the animals' intestinal tract to prevent F from becoming bioavailable.

Moss Bag Results

In 1983 a moss bag survey was conducted around ADR. Moss bags have advantages over indigenous plants in that the moss cannot be contaminated via uptake from a root system; it has a uniform receptor surface and exposures can be made over relatively short durations, usually one calendar month. Moss bags are also inexpensive to use, therefore, more sites can be monitored than with conventional instruments. The development and use of moss bags by the Phytotoxicology Section is explained by Temple et al: "Moss Bags as Monitors of Atmospheric Deposition" APCA Journal, Vol. 31, No. 6, June 1981.

Figure 5 illustrates the location of the 15 moss bag sites established around ADR in September, 1983. The source was shut down during this month. ADR was to resume operations in October; therefore, the bags were exchanged at this time. In total there were four exposure periods corresponding with the calendar months of September, October, November and December. This should have provided one month of shut down data with no operation related emissions, and 3 months of operative data.

There are traces of many elements intrinsic to the moss. To ensure that the exposed moss bag data are indicative only of contaminant deposition from the source during exposure, the exposed moss bag levels were corrected for these background values. This was accomplished by exposing moss bags at a control location, sufficiently removed so as not to be influenced by deposition from the source but close enough to share the same meteorological conditions and regional air quality as the moss bags exposed around the company being monitored. The control location for this survey was site 14, about 4000 m SW of ADR. The average concentration for each element from this site for the October, November and December exposures was subtracted from the levels obtained at all the sites to yield net contaminant deposition results.

The moss bags were analyzed for Al, Cl, S, Na, Mg, F, Cu, Ca and Pb. The Al results from the 4 moss bag exposures are summarized in Table 3 and illustrated in Figure 6. The maximum Al concentration was 1060 ppm detected at site 15, 210 m S of ADR in November. Al levels decreased with increasing distance from the source and were only marginally elevated beyond 1000 m. Site 6, 175 m E had the highest October - December mean Al level of 850 ppm. This compares with 530 ppm Al at this site in September during a period when smelting operations were suspended. November had the highest exposure mean of 223 ppm, compared with 105 ppm for September, 116 ppm in October and 71 ppm for December.

Unlike the foliage and forage data, there was a Ca gradient evident in the moss bag data (Table 4, Figure 7). The levels were considerably elevated very close to ADR, averaging 4950 ppm at site 6, 175 m E. An unexplainably elevated mean level of 2970 ppm was detected at site 11, 1960 m NE of the source. The exposure mean value was highest in November (1157 ppm, mean all 15 sites) and lowest in December (407 ppm).

The Cu concentrations in moss were consistently elevated only at the 2 closest sites, numbers 6 and 15 (summary data Table 5, Figure 8). These sites averaged 37 and 20 ppm, respectively. The exposure means were similar in November and December, 7 and 6 ppm, respectively, and the September exposure mean was the lowest at 2 ppm.

Fluoride was an inconsequential contaminant in moss. Marginally elevated concentrations were detected only at site 6 immediately east of ADR. The F data are summarized in Table 6 and Figure 9. Similarly, Mg levels in moss,

although unquestionably source oriented, were a contaminant of marginal importance (see Table 7, Figure 10). Magnesium moss concentrations in November and December were not significantly different from the September mean value of 17 ppm. However, Mg levels increased substantially at almost all sites in October, which had a monthly exposure mean of 105 ppm.

Sodium levels in moss from the 4 monthly exposures are summarized in Table 8 and the mean (October - December) concentrations at each of the 15 sites is illustrated in Figure 11. Sodium concentrations in moss were much higher at the sites closest to ADR than at surrounding, more distant sampling locations. For example, the October -December mean Na concentration at site 6, 175 m E, was 1050 ppm, compared to 440 ppm at the next closest sampling location (site 15, 210 m S) and generally less than 50 ppm at the remaining sites. The September monthly mean was the lowest (22 ppm), with essentially no Na detected in moss at all but the 2 closest sites. Sodium levels increased substantially at the 2 closest sites in October and November but very little or no Na was detected at other sampling locations. Moss bags are particularly sensitive to deicing salt applied in winter to roads, and in December even the most distant sites, noticeably sites 13 and 14 SW of ADR, contained elevated Na concentrations. However, the Na levels in moss at site 6 rose to 2450 ppm in December from 80 ppm the previous month, indicating that ADR was a considerable Na source during this period. Large parallel increases were not observed at other sites around the source in December; therefore, the Na contamination was extremely localized to the area in the immediate vicinity of ADR.

Sulphur concentrations in moss are summarized in Table 9 and illustrated in Figure 12. Although there was a definite trend toward higher S levels in moss at the sites closest ADR, the levels were generally very low and, like F, considered to be inconsequential in terms of contamination.

Moss bag Cl data are summarized in Table 10 and illustrated in Figure 13. A laboratory error resulted in chromium (Cr) instead of Cl analysis being performed on the November moss bags; therefore, Cl data are not available for this exposure. The Cr levels were uniformly low and are not listed in this report. In September and October virtually no Cl was detected except at the two closest sampling sites. Trace concentrations of Cl were found at all but two sites in December. Chloride, like Na, is a major component of road deicing salt, and application during the December exposure period is the probable cause for detection of this element at this time. Concentrations of Cl found in moss around ADR revealed a weak localized source and the resultant marginal contamination is of no environmental significance.

The Pb data are summarized in Table 11 and illustrated in Figure 14. Very marginally elevated Pb levels were detected at the moss bag sampling sites immediately adjacent to ADR. These levels declined to essentially background beyond 500 m from the source. No Pb was detected at any of the 15 sites in September. Like many of the other elements, the Pb levels are environmentally insignificant.

Conclusions

In 1983 and 1985 Phytotoxicology assessment surveys confirmed that ADR is a source of considerable but localized Al contamination and a marginal source of several other elements. The chemical concentrations of tree foliage tended to be higher for most elements in 1985 compared to 1983. A thorough examination of vegetation in both years revealed no symptoms of air pollution injury on even the most sensitive plant species regardless of their proximity to ADR.

Samples of forage from grazed pastures were collected in both 1983 and 1985. Forage chemical concentrations showed only marginal variation between the two years. Elevated levels of most elements, particularly Al, were detected only at the sampling sites closest to ADR. The forage data were comparable to background control levels beyond about 500 m from the source. The forage data from two animal complaint investigations around ADR were reviewed by cattle specialists from the Ministry of Agriculture and Food and they concluded that the marginal contamination would not inhibit plant growth or yield and that the forage quality was acceptable for cattle consumption. The forage collected during the animal complaint investigations had higher contaminant levels than any of the forage samples collected during the 1983 and 1985 general assessment surveys in the vicinity of ADR.

The moss bag survey conducted in the late summer and fall of 1983 confirmed that ADR is a source of Al, Cu, F, Na and Pb atmospheric deposition. Of these 5 chemicals only Al and Na appeared to be emitted in significant quantities. The moss bag data confirmed that emissions from ADR were localized in extent and the foliage, forage and visual observations confirmed that the environmental impact on the surrounding terrestrial ecosystem was negligible.

Calcium, Mg, S and Cl also appeared to be associated with either emissions from the manufacturing process or fugitive dust from the general activity around ADR. These elements tended to be dispersed over a slightly greater area.

However, Ca, Mg and S are plant macronutrients and are required in relatively large amounts to fuel plant metabolic processes. Chloride is a micronutrient, essential to plant growth but required in smaller amounts than the macronutrients. These nutrient type elements also can be phytotoxic if present in high concentrations; however the lack of injury symptoms on even the most sensitive plant species indicated that emissions of Ca, Mg and S were not excessive.

The levels of most chemicals in moss tended to be lower in September when ADR was not operating and higher (but variable) in October, November and December.

In conclusion, emissions from ADR have had a negligible impact on the vegetation in the Ravenshoe area and although contamination of forage has occurred, it is extremely localized and acceptable for cattle consumption. The Phytotoxicology Section will continue to monitor the soil and vegetation in the vicinity of this source on a periodic basis or as requested by MOE Central Region.

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TABLE 1

**Concentrations of Various Chemicals in Unwashed Poplar Foliage
in the Vicinity of Aluminum Dross Recycling, Keswick
1983 and 1985**

Distance and Direction from Source**			Chemical Concentration *									
			Al	Ca	Cl%	Cu	F	Mg	Mo	Na	Pb	S%
1	300 m NNW	1983	410	11500	0.70	19	12	3350	NA	118	8	0.22
		1985	370	11400	0.60	17	9	5250	0.5	130	5	0.14
2	325 m N	1983	325	13500	1.04	14	11	2100	NA	178	8	0.19
		1985	1150	12000	0.90	43	14	3100	<0.5	325	12	0.17
5	500 m NNW	1983	130	14000	0.35	9	5	1150	NA	80	5	0.16
		1985	130	22500	0.74	12	7	2000	<0.5	62	2	0.19
7	500 m S	1983	375	16500	0.50	8	5	2400	NA	39	2	0.27
		1985	425	18000	0.49	8	6	2000	0.5	36	3	0.20
3	550 m SSE	1983	130	18000	0.28	12	4	1100	NA	51	4	0.23
		1985	140	22500	0.46	11	6	1950	<0.5	51	3	0.15
6	1000 m NNW	1983	145	22000	0.64	9	4	2100	NA	74	3	0.17
		1985	430	32000	1.48	11	7	1150	<0.5	290	4	0.14
8	Control 2850 m S	1983	44	15000	0.40	6	5	2750	NA	31	2	0.19
		1985	110	20000	0.37	8	3	2300	<0.5	22	2	0.17
Mean		1983	223	15800	0.56	11	7	2140	NA	82	5	0.20
		1985	394	19800	0.72	16	7	2540	<0.5	131	4	0.17
Phytotoxicology Upper Limits of Normal			500	30000	0.15	20	15	7000	1.5	50	30	0.40

* parts per million (except where noted), dry weight, mean of replicate samples.

NA not analyzed

** approx. distance/direction from the centre of the ADR building

TABLE 2

**Concentrations of Various Chemicals in Forage
in the Vicinity of Aluminum Dross Recycling, Keswick
1983 and 1985**

Distance and Direction from Source**			Chemical Concentration *									
			Al	Ca	Cl%	Cu	F	Mg	Mo	Na	Pb	S%
1	250 m E	1983	820	9400	NA	28	5	2100	NA	265	10	0.26
		1985	585	16500	1.62	22	<1	1400	1.2	1050	6	0.23
2	425 m NNW	1983	75	5950	NA	11	1	2700	NA	51	<1	0.38
		1985	330	10000	1.47	13	3	2150	3.4	145	2	0.33
3	550 m SSE	1983	87	7100	NA	5	1	2250	NA	120	2	0.29
		1985	58	8550	1.25	5	1	1750	1.3	141	1	0.26
4	1375 m NW	1983	86	6700	NA	5	<1	1800	NA	140	<1	0.24
		1985	54	7900	0.52	6	<1	2200	1.5	32	<1	0.26
5	1625 m NE	1983	68	5800	NA	4	<1	3000	NA	300	<1	0.29
		1985	205	13000	0.70	3	<1	900	0.6	100	2	0.19
6	Control 5000 m SW	1983	42	5900	NA	7	<1	2800	NA	230	<1	0.27
		1985	32	5100	1.08	9	<1	1000	0.7	35	1	0.21
Mean		1983	168	5840	NA	9	1	2090	NA	158	2	0.25
		1985	181	8750	0.95	8	<1	1340	1.2	215	2	0.21
Phytotoxicology Upper Limits of Normal			NE	NE	1.00	7	12	NE	6	NE	20	0.50

* parts per million (except where noted), dry weight, mean of replicate samples.

NA not analyzed

NE not established

** approx. distance/direction from the centre of the ADR building

TABLE 3
Aluminum Concentration in Moss Bags Exposed in the Vicinity
of Aluminum Dross Recycling
September to December, 1983

Site No.	Distance and Direction from Source**	Aluminum Concentration*					Mean (Oct.-Dec.)
		Sept.	Oct.	Nov.	Dec.		
6	175 m E	530	1040	770	740	850	
15	210 m S	540	100	1060	170	440	
7	245 m NNW	30	0	80	0	27	
4	490 m SSE	110	200	370	0	190	
5	525 m W	90	10	110	0	40	
8	525 m NNW	0	20	120	0	47	
2	735 m E	55	90	100	110	100	
9	1260 m WNW	40	0	10	0	3	
10	1330 m NE	0	0	130	0	43	
3	1470 m E	30	0	140	0	47	
1	1680 m ESE	40	160	70	30	87	
11	1960 m NE	80	60	180	20	87	
12	2275 m ENE	20	30	80	0	55	
13	2590 m SW	10	30	80	0	55	
14	3990 m SW	0	0	50	0	17	
Mean		105	116	223	71	139	

* parts per million, dry weight, single sample, corrected for background.

Aluminum background correction = 760 ppm

** approx. distance/direction from the centre of the ADR building

TABLE 4

Calcium Concentration in Moss Bags Exposed in the Vicinity
of Aluminum Dross Recycling
September to December, 1983

Site No.	Distance and Direction from Source**	Calcium Concentration*					Mean (Oct.-Dec.)
		Sept.	Oct.	Nov.	Dec.		
6	175 m E	5470	6200	5560	3100	4950	
15	210 m S	2390	1000	2110	100	1070	
7	245 m NNW	280	300	310	0	200	
4	490 m SSE	130	700	390	0	360	
5	525 m W	590	700	520	1600	940	
8	525 m NNW	0	300	10	0	100	
2	735 m E	210	900	320	0	410	
9	1260 m WNW	90	0	70	0	23	
10	1330 m NE	0	0	30	0	10	
3	1470 m E	80	100	1610	0	570	
1	1680 m ESE	40	1000	430	0	480	
11	1960 m NE	2320	2000	5600	1300	2970	
12	2275 m ENE	170	0	120	0	40	
13	2590 m SW	260	0	270	0	90	
14	3990 m SW	70	0	0	0	0	
Mean		807	880	1157	407	814	

* parts per million, dry weight, single sample, corrected for background.

Calcium background correction = 3200 ppm

** approx. distance/direction from the centre of the ADR building

TABLE 5

Copper Concentration in Moss Bags Exposed in the Vicinity
of Aluminum Dross Recycling
September to December, 1983

Site No.	Distance and Direction from Source**	Copper Concentration*					Mean (Oct.-Dec.)
		Sept.	Oct.	Nov.	Dec.		
6	175 m E	17	40	24	46	37	
15	210 m S	13	5	40	14	20	
7	245 m NNW	0	0	15	3	6	
4	490 m SSE	2	3	15	3	7	
5	525 m W	0	1	2	3	2	
8	525 m NNW	0	0	0	3	1	
2	735 m E	0	1	0	4	2	
9	1260 m WNW	0	0	0	3	1	
10	1330 m NE	0	0	0	3	1	
3	1470 m E	0	0	0	3	1	
1	1680 m ESE	0	2	1	3	2	
11	1960 m NE	0	2	10	3	5	
12	2275 m ENE	0	0	0	2	1	
13	2590 m SW	1	0	0	2	1	
14	3990 m SW	0	0	0	2	1	
Mean		2	4	7	6	6	

* parts per million, dry weight, single sample, corrected for background.

Copper background correction = 4 ppm

** approx. distance/direction from the centre of the ADR building

TABLE 6

Fluoride Concentration in Moss Bags Exposed in the Vicinity
of Aluminum Dross Recycling
September to December, 1983

Site No.	Distance and Direction from Source**	Fluoride Concentration*					Mean (Oct.-Dec.)
		Sept.	Oct.	Nov.	Dec.		
6	175 m E	2	29	1	5	12	
15	210 m S	0	0	2	0	1	
7	245 m NNW	0	0	0	0	0	
4	490 m SSE	0	0	0	0	0	
5	525 m W	0	0	0	0	0	
8	525 m NNW	0	0	0	0	0	
2	735 m E	0	0	0	0	0	
9	1260 m WNW	0	0	0	0	0	
10	1330 m NE	0	0	0	2	1	
3	1470 m E	0	0	0	0	0	
1	1680 m ESE	0	0	0	0	0	
11	1960 m NE	1	0	0	0	0	
12	2275 m ENE	0	0	0	0	0	
13	2590 m SW	0	0	0	0	0	
14	3990 m SW	0	0	0	0	0	
Mean		0	2	0	0	1	

* parts per million, dry weight, single sample, corrected for background.

Fluoride background correction = 2 ppm

** approx. distance/direction from the centre of the ADR building

TABLE 7

**Magnesium Concentration in Moss Bags Exposed in the Vicinity
of Aluminum Dross Recycling
September to December, 1983**

Site No.	Distance and Direction from Source**	Magnesium Concentration*					Mean (Oct.-Dec.)
		Sept.	Oct.	Nov.	Dec.		
6	175 m E	90	250	100	150	170	
15	210 m S	120	50	160	0	70	
7	245 m NNW	0	50	0	0	17	
4	490 m SSE	0	250	0	0	83	
5	525 m W	0	40	0	50	30	
8	525 m NNW	0	50	0	0	17	
2	735 m E	0	450	0	40	170	
9	1260 m WNW	0	0	0	0	0	
10	1330 m NE	0	0	0	0	0	
3	1470 m E	0	50	0	0	17	
1	1680 m ESE	0	250	0	20	100	
11	1960 m NE	50	50	20	10	27	
12	2275 m ENE	0	50	0	0	17	
13	2590 m SW	0	40	0	30	23	
14	3990 m SW	0	0	0	0	0	
Mean		17	105	19	20	49	

* parts per million, dry weight, single sample, corrected for background.

Magnesium background correction = 950 ppm

** approx. distance/direction from the centre of the ADR building

TABLE 8
Sodium Concentration in Moss Bags Exposed in the Vicinity
of Aluminum Dross Recycling
September to December, 1983

Site No.	Distance and Direction from Source**	Sodium Concentration*					Mean (Oct.-Dec.)
		Sept.	Oct.	Nov.	Dec.		
6	175 m E	130	640	80	2450	1050	
15	210 m S	200	70	770	490	440	
7	245 m NNW	0	0	0	10	3	
4	490 m SSE	0	0	90	20	37	
5	525 m W	0	0	0	0	0	
8	525 m NNW	0	0	0	0	0	
2	735 m E	0	0	0	110	37	
9	1260 m WNW	0	0	0	30	10	
10	1330 m NE	0	0	0	20	7	
3	1470 m E	0	0	50	30	27	
1	1680 m ESE	0	0	0	50	17	
11	1960 m NE	0	0	0	100	33	
12	2275 m ENE	0	0	0	50	17	
13	2590 m SW	0	0	0	180	60	
14	3990 m SW	0	0	0	310	100	
Mean		22	47	66	257	123	

* parts per million, dry weight, single sample, corrected for background.

Sodium background correction = 150 ppm

** approx. distance/direction from the centre of the ADR building

TABLE 9
Sulphur Concentration in Moss Bags Exposed in the Vicinity
of Aluminum Dross Recycling
September to December, 1983

Site No.	Distance and Direction from Source**	Sulphur Concentration*					Mean (Oct.-Dec.)
		Sept.	Oct.	Nov.	Dec.		
6	175 m E	0.00	0.07	0.03	0.07	0.06	
15	210 m S	0.01	0.01	0.03	0.05	0.03	
7	245 m NNW	0.00	0.00	0.00	0.02	0.01	
4	490 m SSE	0.00	0.00	0.00	0.02	0.01	
5	525 m W	0.00	0.00	0.00	0.00	0.00	
8	525 m NNW	0.00	0.01	0.01	0.01	0.01	
2	735 m E	0.01	0.02	0.01	0.05	0.03	
9	1260 m WNW	0.00	0.00	0.01	0.01	0.01	
10	1330 m NE	0.00	0.00	0.00	0.03	0.01	
3	1470 m E	0.00	0.00	0.01	0.03	0.01	
1	1680 m ESE	0.00	0.01	0.00	0.03	0.01	
11	1960 m NE	0.01	0.01	0.02	0.07	0.03	
12	2275 m ENE	0.00	0.00	0.00	0.03	0.01	
13	2590 m SW	0.00	0.01	0.00	0.03	0.01	
14	3990 m SW	0.00	0.00	0.00	0.00	0.00	
Mean		0	0.01	0.01	0.03	0.02	

* percent, dry weight, single sample, corrected for background.

Sulphur background correction = 0.07%

** approx. distance/direction from the centre of the ADR building

TABLE 10

Chloride Concentration in Moss Bags Exposed in the Vicinity
of Aluminum Dross Recycling
September to December, 1983

Site No.	Distance and Direction from Source**	Chloride Concentration*					Mean (Oct.-Dec.)
		Sept.	Oct.	Nov.	Dec.		
6	175 m E	0.09	0.22	N	0.57	0.40	
15	210 m S	0.03	0.01	O	0.07	0.04	
7	245 m NNW	0.00	0.00		0.00	0.00	
4	490 m SSE	0.00	0.00	D	0.01	0.01	
5	525 m W	0.00	0.00	A	0.00	0.00	
8	525 m NNW	0.00	0.03	T	0.00	0.02	
2	735 m E	0.00	0.01	A	0.03	0.02	
9	1260 m WNW	0.00	0.00		0.00	0.00	
10	1330 m NE	0.00	0.00		0.01	0.01	
3	1470 m E	0.00	0.00		0.01	0.01	
1	1680 m ESE	0.00	0.00		0.01	0.01	
11	1960 m NE	0.00	0.00		0.02	0.01	
12	2275 m ENE	0.00	0.00		0.01	0.01	
13	2590 m SW	0.00	0.00		0.03	0.02	
14	3990 m SW	0.00	0.00		0.02	0.01	
Mean		0.01	0.02		0.05	0.04	

* percent, dry weight, single sample, corrected for background.

Chlorine background correction = 0.02%

** approx. distance/direction from the centre of the ADR building

TABLE 11
Lead Concentration in Moss Bags Exposed in the Vicinity
of Aluminum Dross Recycling
September to December, 1983

Site No.	Distance and Direction from Source**	Lead Concentration*					Mean (Oct.-Dec.)
		Sept.	Oct.	Nov.	Dec.		
6	175 m E	0	7	7	11		8
15	210 m S	0	0	5	0		2
7	245 m NNW	0	0	2	0		1
4	490 m SSE	0	1	4	0		2
5	525 m W	0	0	0	0		0
8	525 m NNW	0	0	0	0		0
2	735 m E	0	0	0	0		0
9	1260 m WNW	0	0	0	0		0
10	1330 m NE	0	0	0	0		0
3	1470 m E	0	0	0	0		0
1	1680 m ESE	0	2	0	0		1
11	1960 m NE	0	0	2	0		1
12	2275 m ENE	0	0	0	0		0
13	2590 m SW	0	0	1	0		0
14	3990 m SW	0	0	1	0		0
Mean		0	1	1	1		1

* parts per million, dry weight, single sample, corrected for background.

Lead background correction = 20 ppm

** approx. distance/direction from the centre of the ADR building

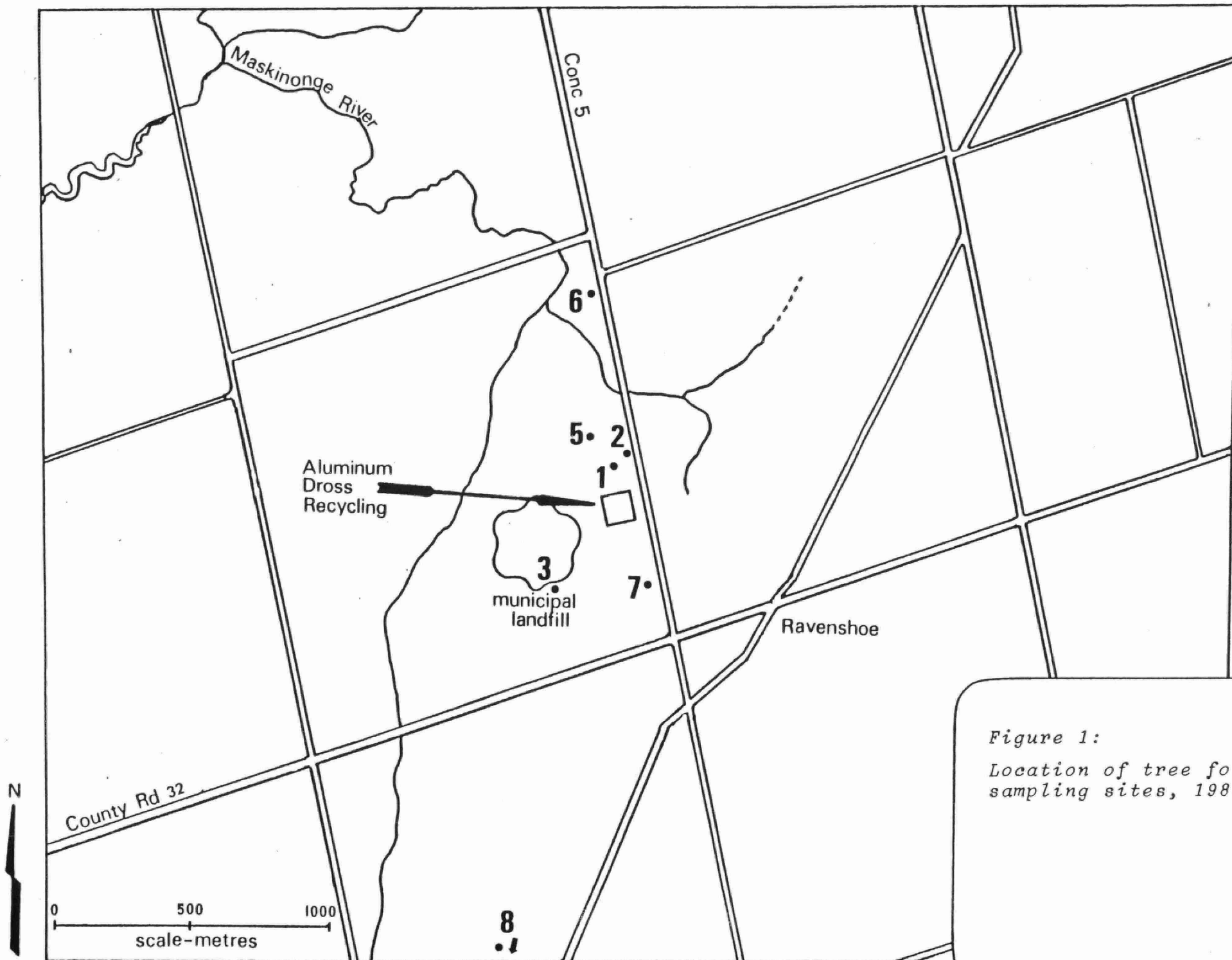


Figure 1:
Location of tree foliage
sampling sites, 1983 & 1985

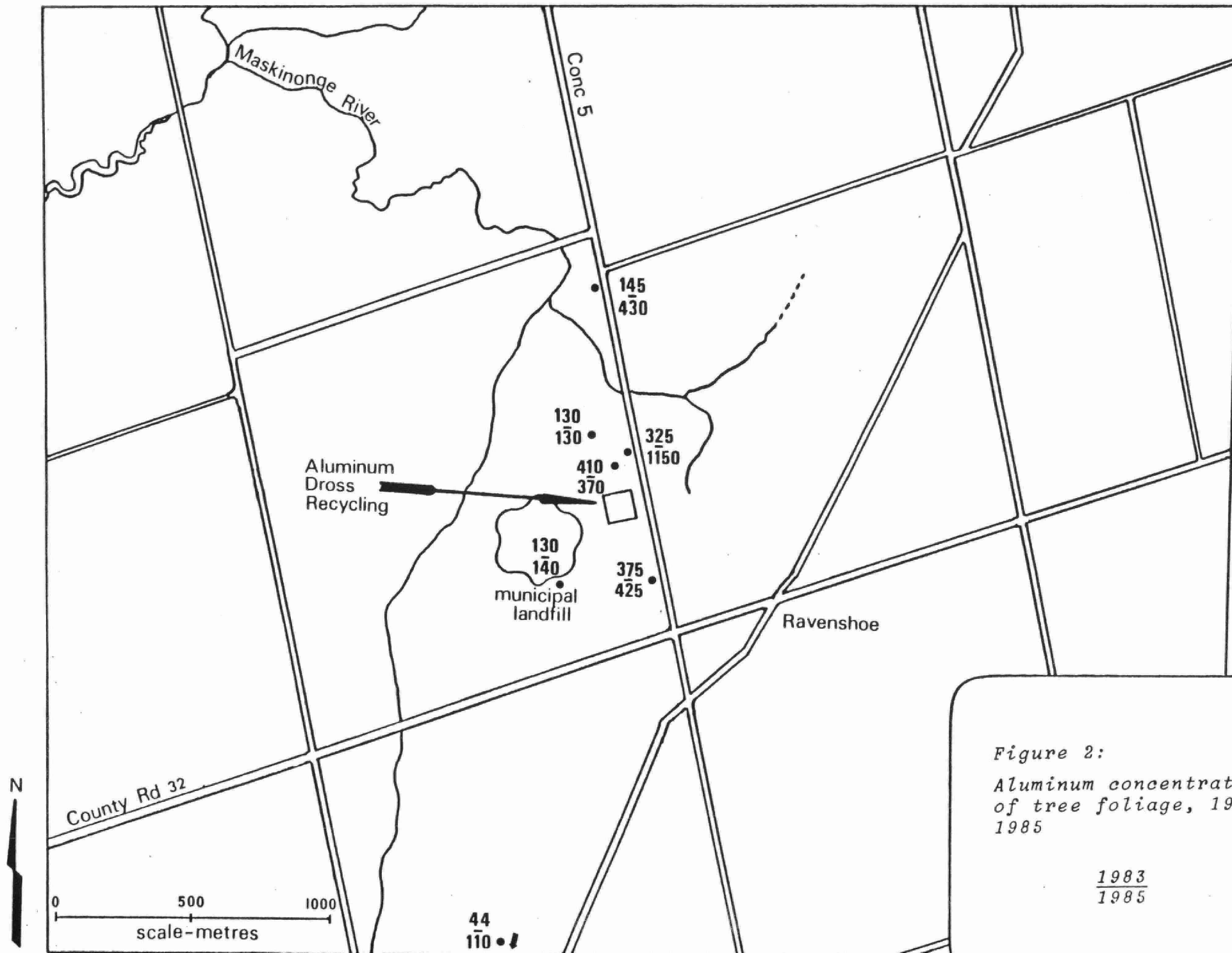


Figure 2:
Aluminum concentration
of tree foliage, 1983 &
1985

$\frac{1983}{1985}$

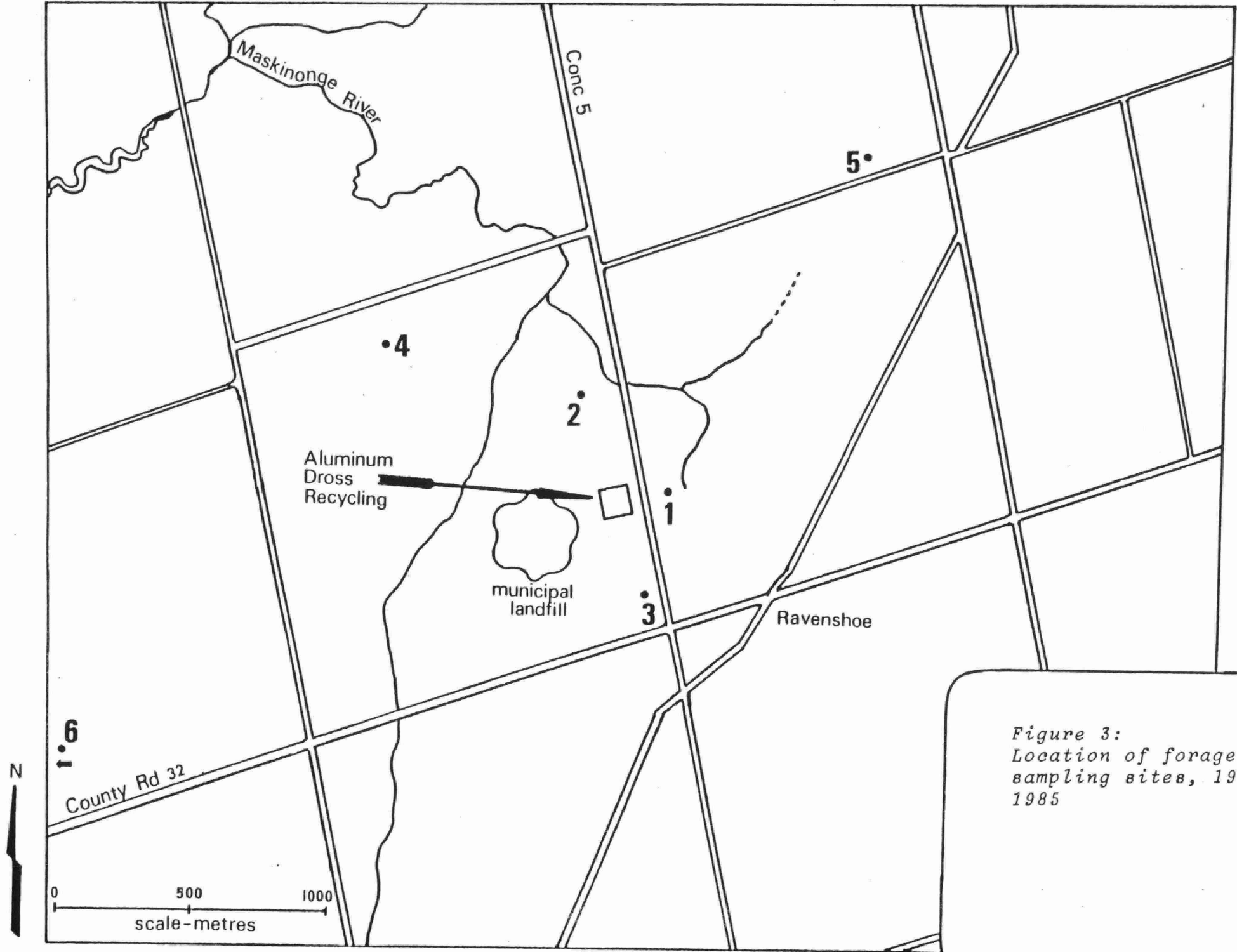
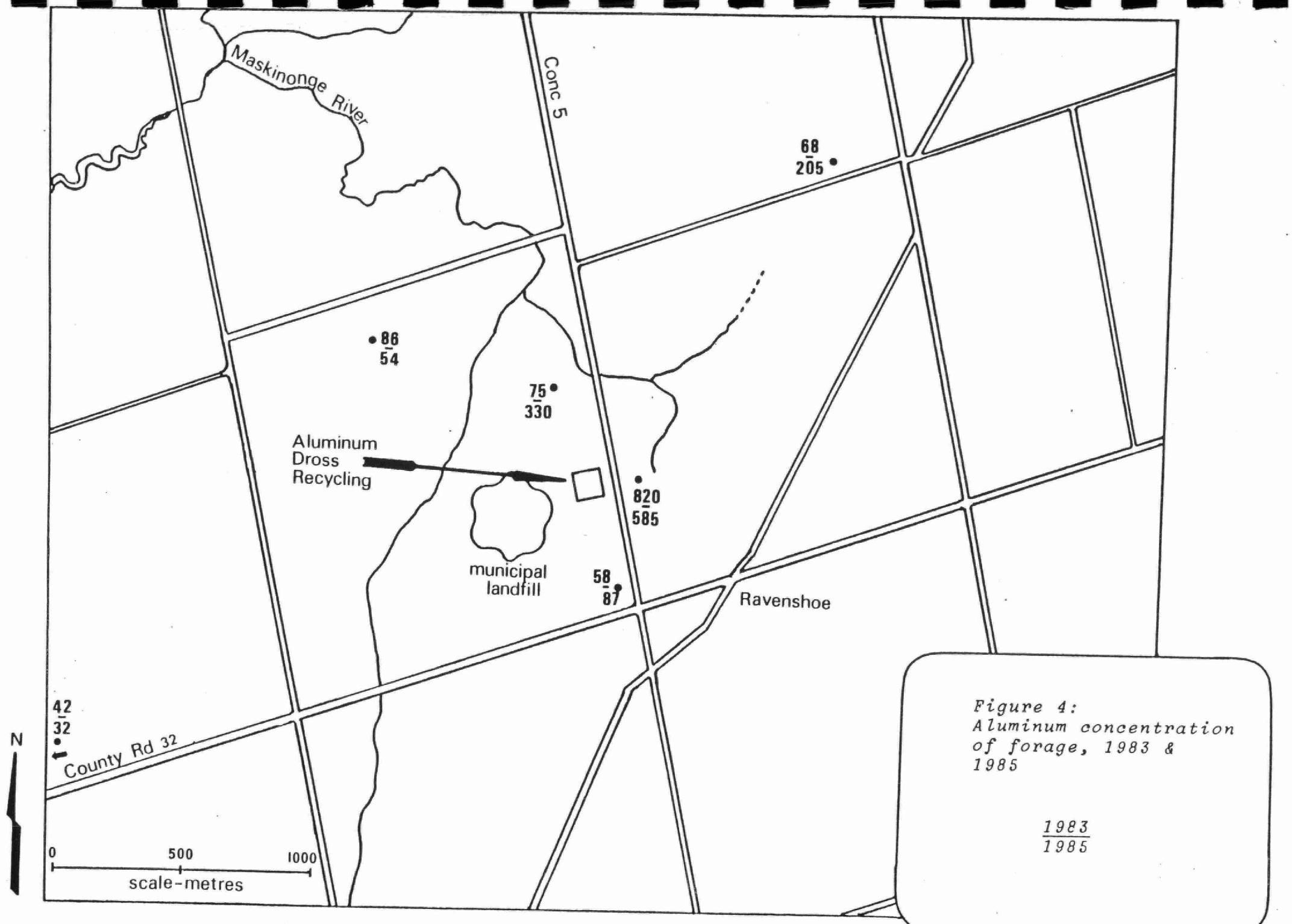


Figure 3:
Location of forage
sampling sites, 1983 &
1985



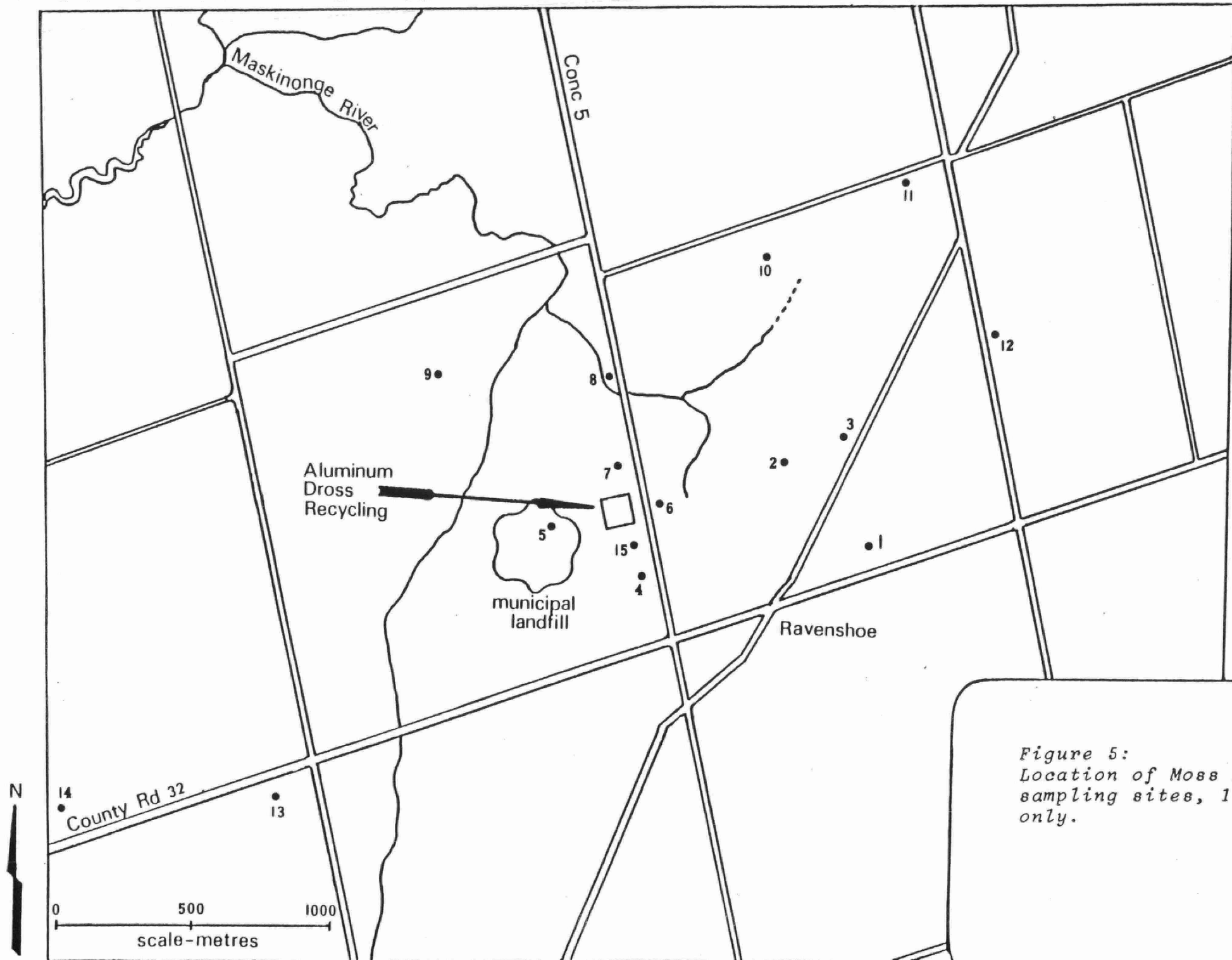


Figure 5:
Location of Moss Bag
sampling sites, 1983
only.

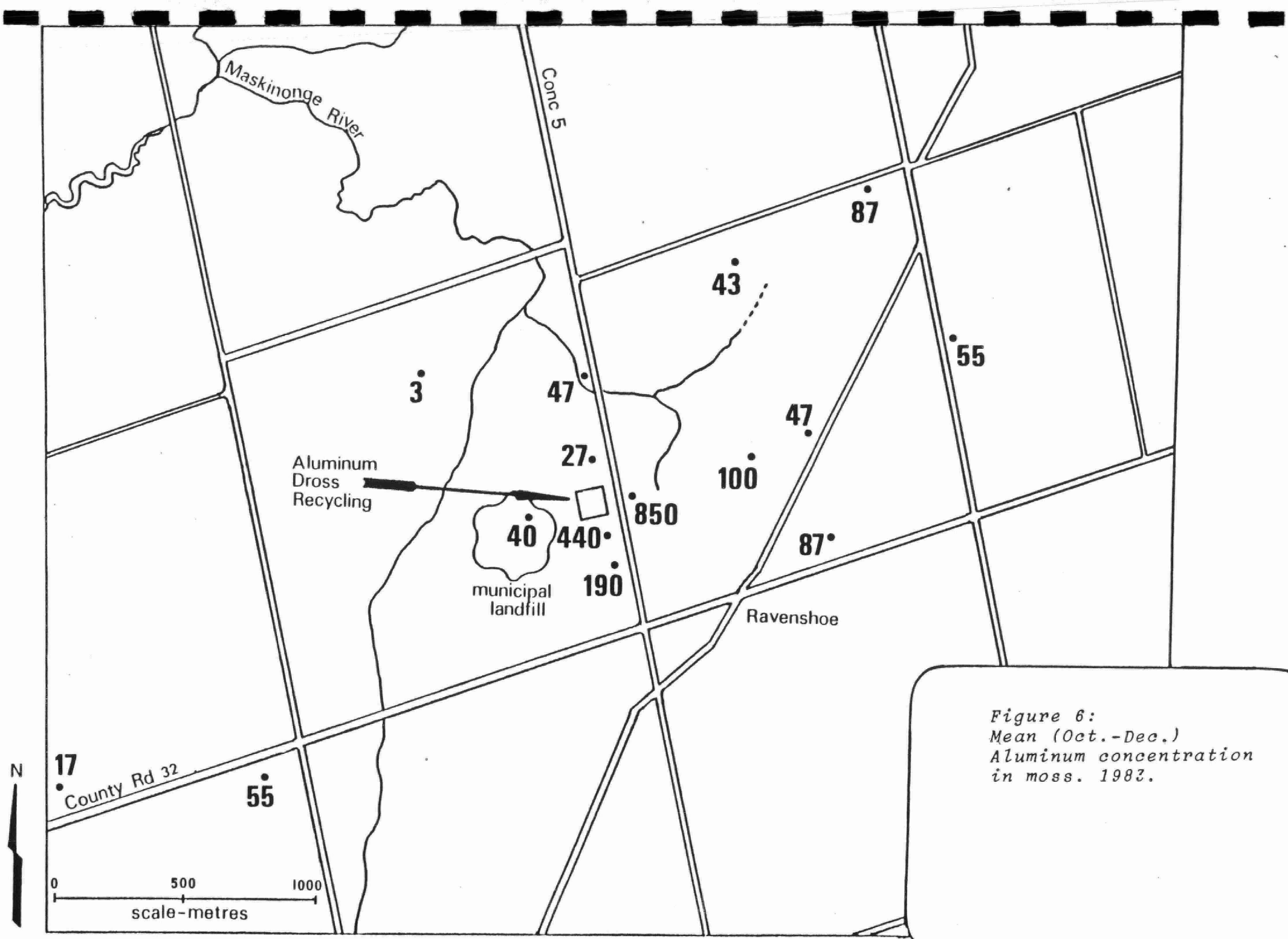


Figure 6:
Mean (Oct.-Dec.)
Aluminum concentration
in moss. 1983.

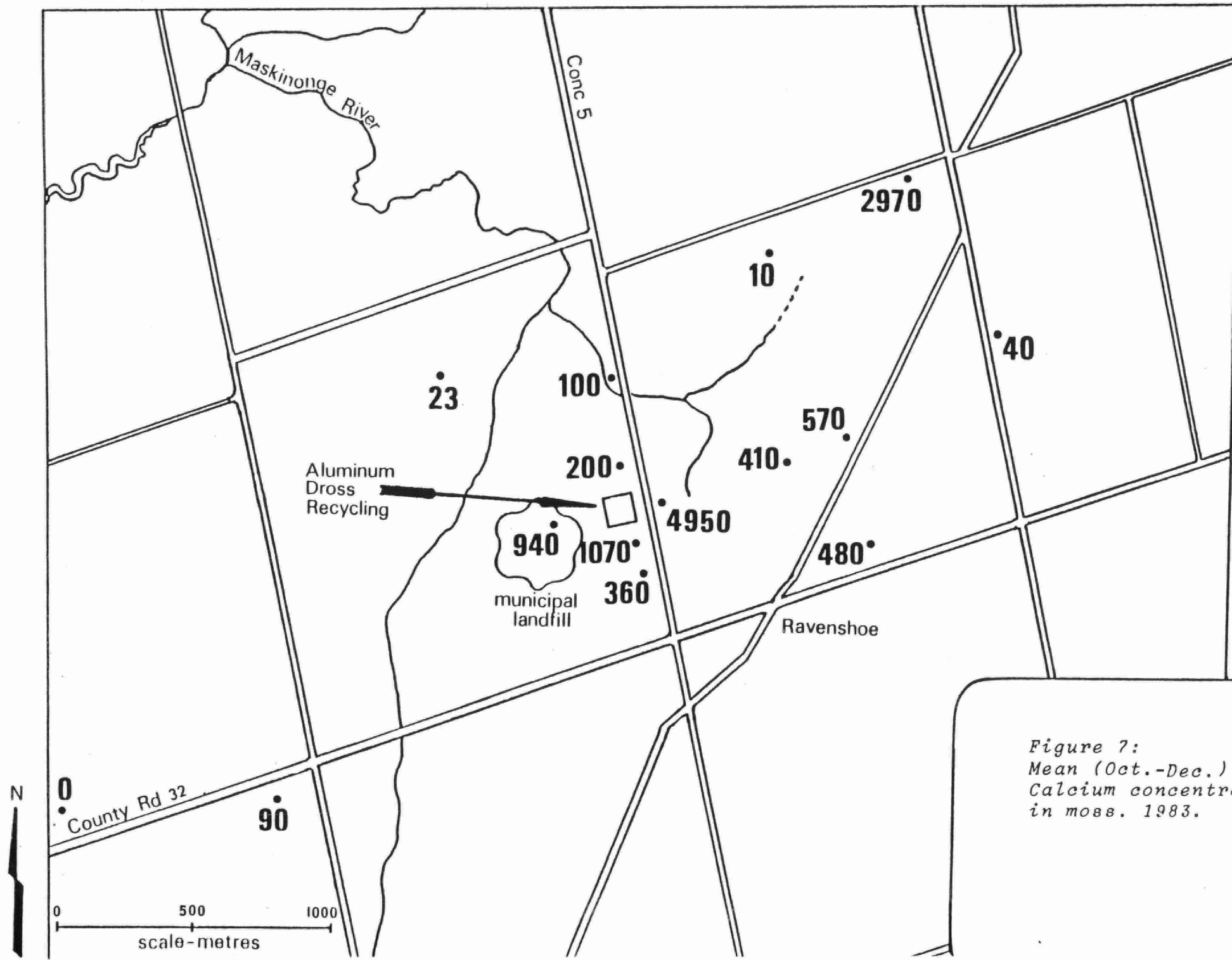


Figure 7:
Mean (Oct.-Dec.)
Calcium concentration
in moss. 1983.

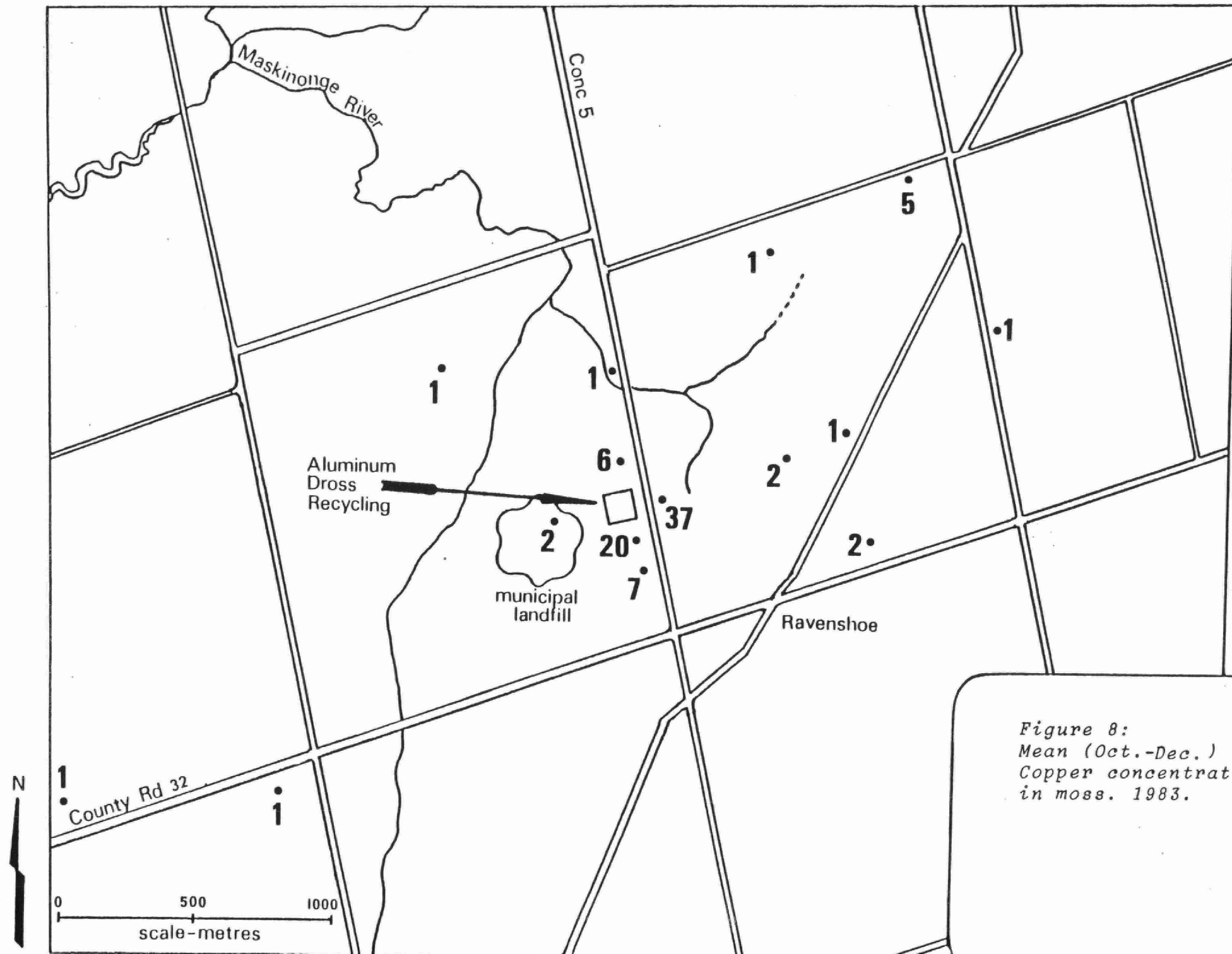


Figure 8:
Mean (Oct.-Dec.)
Copper concentration
in moss. 1983.

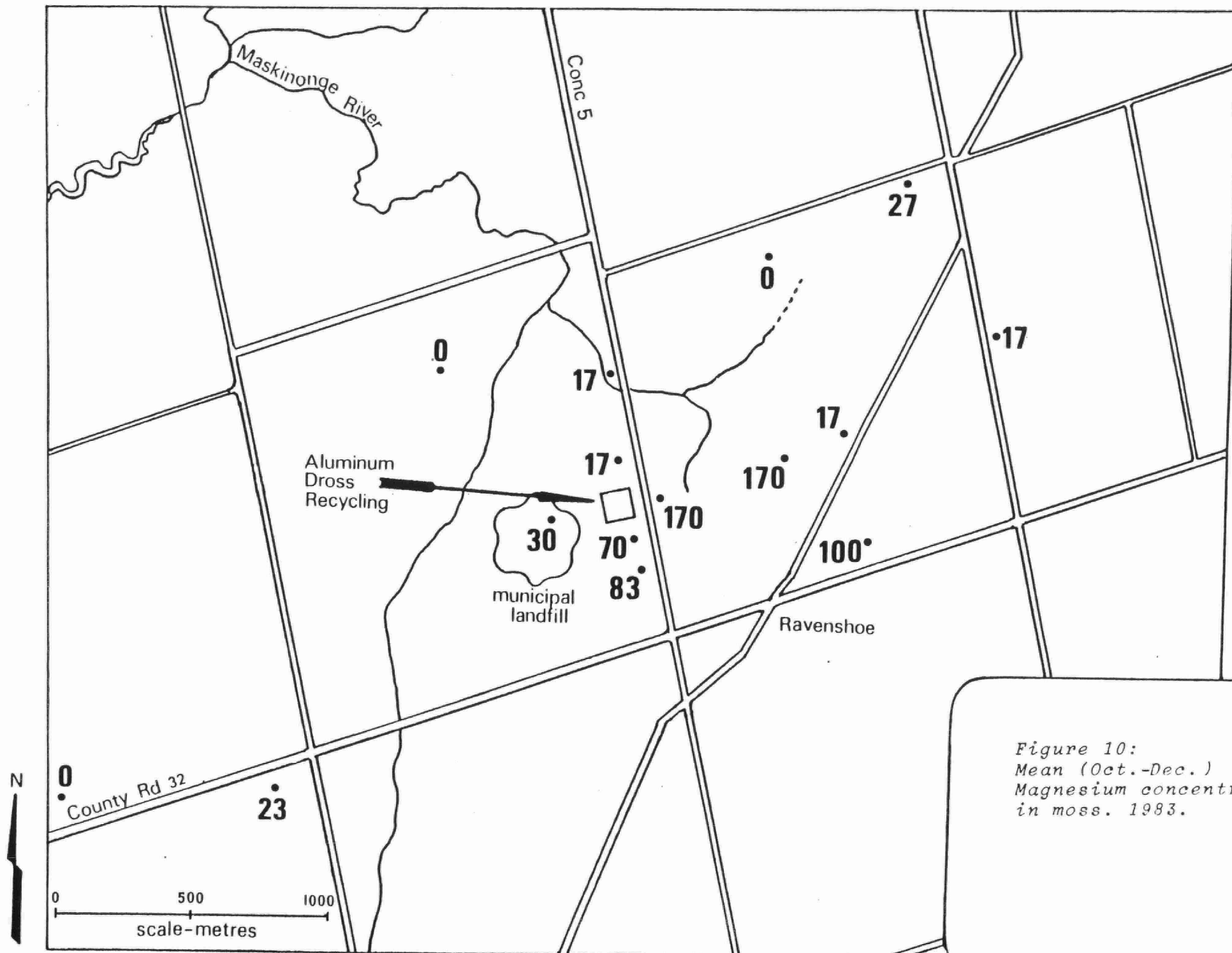
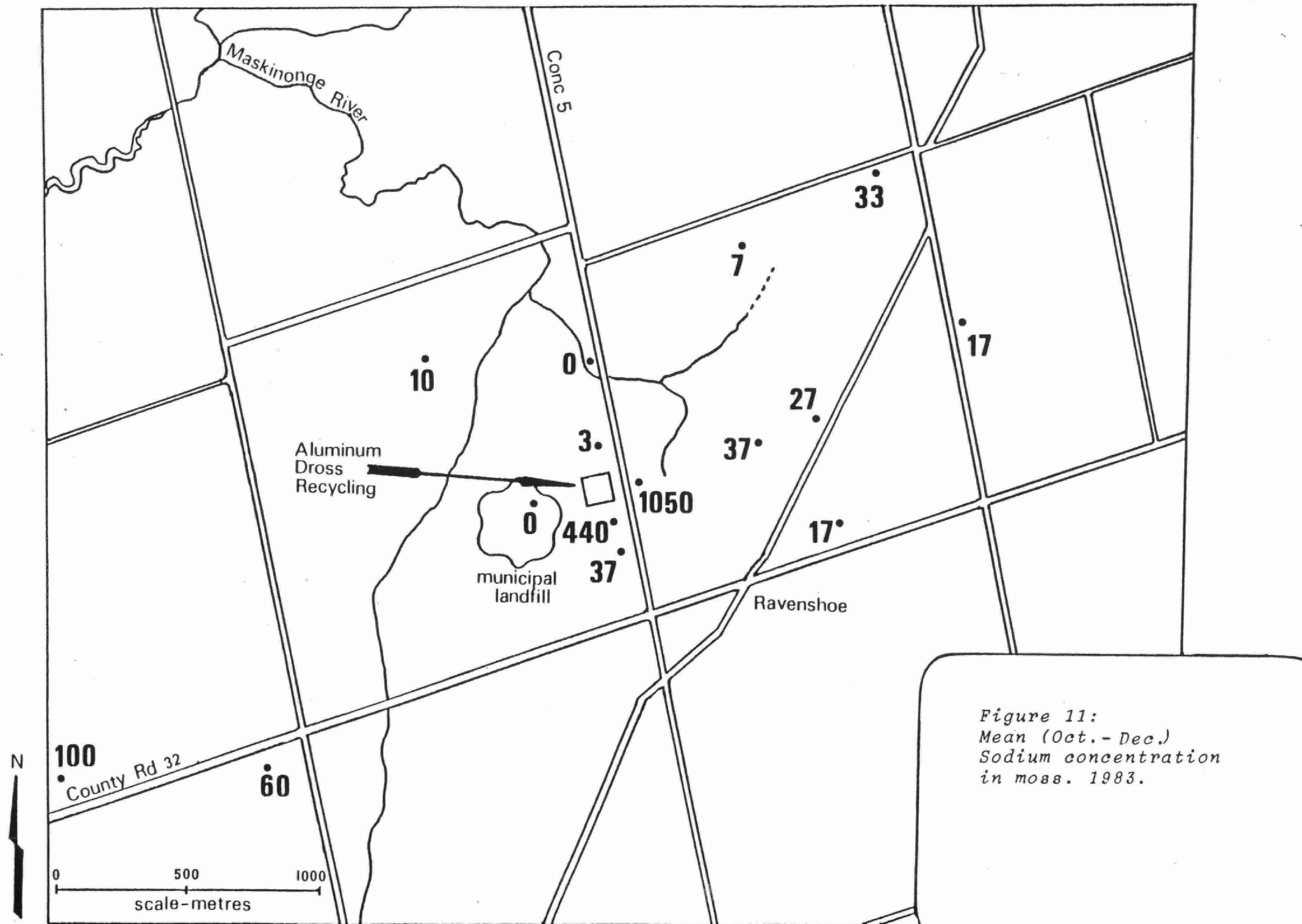


Figure 10:
Mean (Oct.-Dec.)
Magnesium concentration
in moss. 1983.



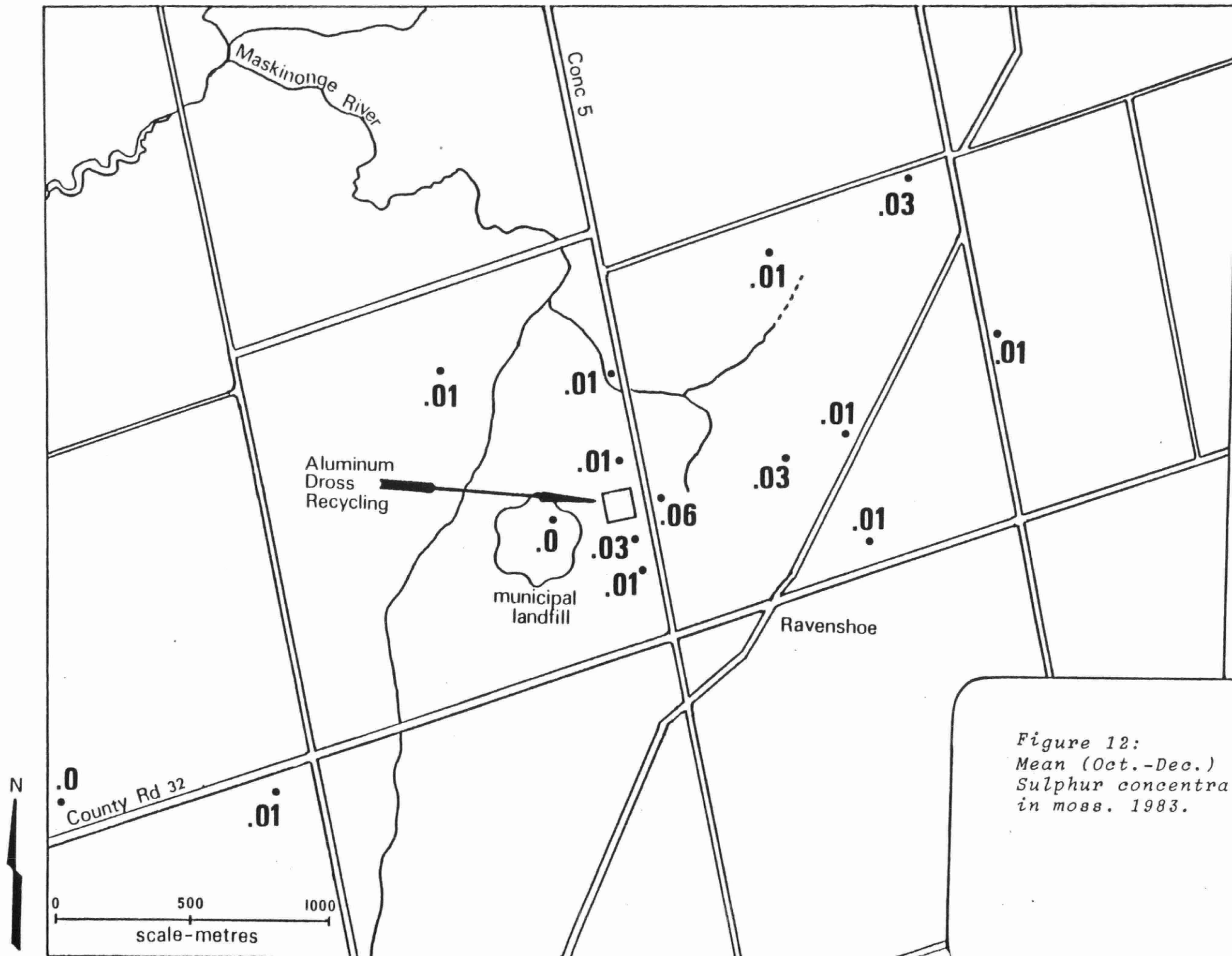
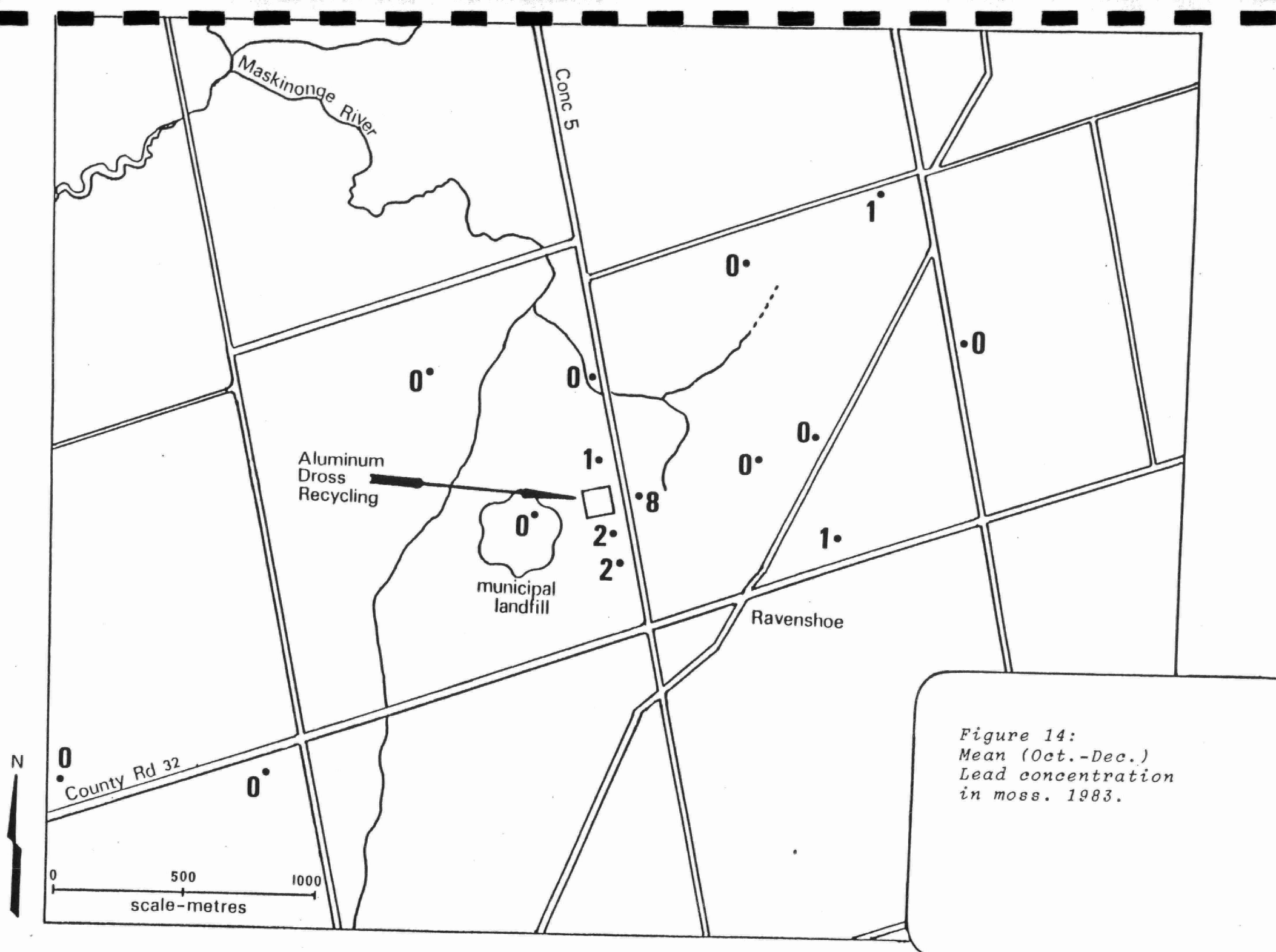


Figure 12:
Mean (Oct.-Dec.)
Sulphur concentration
in moss. 1983.





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